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AN EVALUATION OF A RUBBER-COATED STEEL DRUM VIBRATORY ROLLER

MATERIALS INFORMATION
ENGINEERING MATERIALS OFFICE

AN EVALUATION OF A RUBBER-COATED STEEL DRUM VIBRATORY ROLLER

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ABSTRACT

To improve the surface frictional properties of hot mix pavements, Dynapac has introduced a rubber-coated steel drum roller. The steel drums of the vibratory roller are coated with 40 mm of rubber. Theoretically, the flexible rubber coating will improve the macro-texture of the pavement surface.

In the fall of 1986, the Ministry arranged for the rubber-coated roller to be tested on two contracts. Trial areas of HL-1, and Dense Friction Course (DFC) mix were constructed, with control areas placed adjacent to each trial area.

The compaction of the DFC mix in the control areas was 1% higher than that in the area compacted by the rubber-coated roller. The compaction of the HL-1 mix rolled by the conventional train was the same as that achieved by the rubber-coated roller.

Preliminary friction testing, using the brake-force trailer on the HL-1 surface course, indicated higher friction numbers (more desirable frictional characteristics) from the conventional area than from the area compacted by the rubber-coated roller. However, the results are limited. Further friction surveys and photo-interpretation of the surface texture will be carried out in the spring of 1987, at which time an in-depth analysis of the frictional properties can be done.

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1.0 INTRODUCTION

An important quality of Ontario highways is the frictional characteristics of the pavement surface. To improve the frictional characteristics of the surface course, Dynapac has introduced a rubber-coated steel drum, vibratory roller. This rubber-coated roller would replace the entire conventional rolling train. In theory, the flexible rubber coating will improve the macro-texture of the pavement surface. If the roller is successful, the stone content of HL-1 and DFC mixes could possibly be reduced without compromising their present frictional quality. Such a reduction in coarse aggregate content, would lower mix permeability and may aid in compaction.

The Ministry arranged a trial of the Dynapac roller on two different contracts in the fall of 1986. Test areas of Dense Friction Course mix and of HL-1 surface course were compacted by the rubber-coated roller and compared to adjacent control areas. This report details the construction and the performance of the test sections to date.

2.0 EQUIPMENT

2.1 Rubber-Coated Roller

The Dynapac roller (CC42R) is a vibratory, steel drum roller. Each steel drum is covered with 40 mm of rubber as shown in Fig. 1. To prevent asphalt pick-up the spray bar utilizes diesel fuel, instead of water. The diameter of the spray nozzles along the spray bar has been reduced to half the original size, to accommodate the diesel fuel.

Fig. 1 - Rubber-Coated Steel Drum

The rubber-coated roller replaces the entire conventional rolling train. The use of any other rollers would interfere with the surface texture produced by the Dynapac roller. Both the Ministry and Dynapac were concerned about the level of compaction that would be achieved by the single roller. Concern was also expressed by Dynapac about the level of compaction that could be achieved along a longitudinal joint, particularly a cold joint.

2.2 Conventional Rolling Train

2.2.1 Contract 85-39

The conventional rolling train, to be used in the control areas on Contract 85-39, consisted of three rollers. A tandem steel drum vibratory roller (Dynapac CC50A) was followed by a rubber-tired roller, and then a Bros SP6000B finishing roller. However, as detailed in 4.1, only the first 300 m of the control area were compacted with the rolling train described. Due to excessive pick-up, the rubber-tired roller was replaced by a second steel drum roller (Dynapac CC50A). The two steel drum rollers (the second used in the static mode only) were used as the rolling train on the remainder of the control areas.

2.2.2 Contract 85-40

On Contract 85-40, the contractor's rolling train consisted of a Dynapac steel drum vibratory roller (CC42), an Ingram rubber-tired roller, and a Hyster finishing roller (Fig. 2).

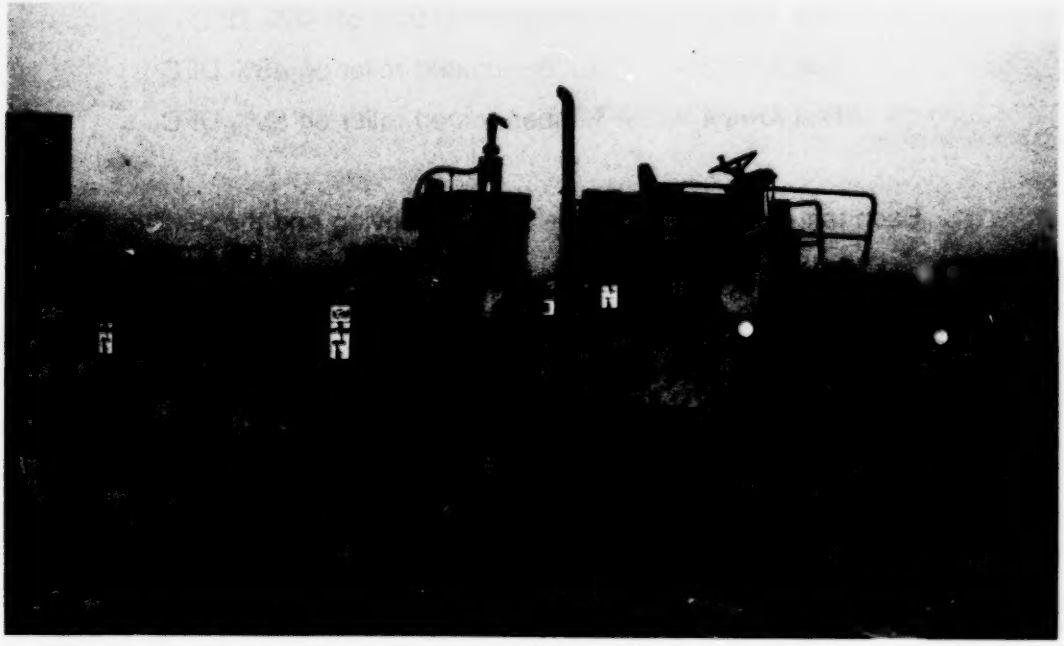


Fig. 2 - Conventional Rolling Train, Contract 85-40

3.0 LOCATION OF TEST SECTIONS

A test section using the rubber-coated roller was placed on two contracts in Port Hope District. A test section was located on Contract 85-39 (Highway 35/115), and on Contract 85-40 (Highway 115 at Highway 28).

3.1 Contract 85-39

A test section of Dense Friction Course (DFC) mix was placed on Contract 85-39. The test section is located in the northbound lanes of Highway 35/115, from station 17+100 to 19+450 (refer to Fig. 3 for Contract location).

Because DFC at two different coarse aggregate contents was being placed on this contract, the opportunity to carry out a trial on both pavements was taken. Test areas were constructed using the rubber-coated roller and the conventional train on both 45% and 55% coarse aggregate DFC. Four different test areas resulted:

Test Area 1 - Conventional train on 55% DFC
Test Area 2 - Conventional train on 45% DFC
Test Area 3 - Rubber-coated roller on 45% DFC
Test Area 4 - Rubber-coated roller on 55% DFC

Each test area was placed in both the driving and the passing lane, due to the different traffic conditions in the two lanes. Each area extended approximately 550 m in each lane. Because paving of the two lanes was done in echelon, the areas were staggered so that one rolling train did not have to cover both lanes at the same time. (Only one rubber-coated roller was available and can follow only one paver at a time.) A diagram showing the location of each test area can be found in Appendix 1.

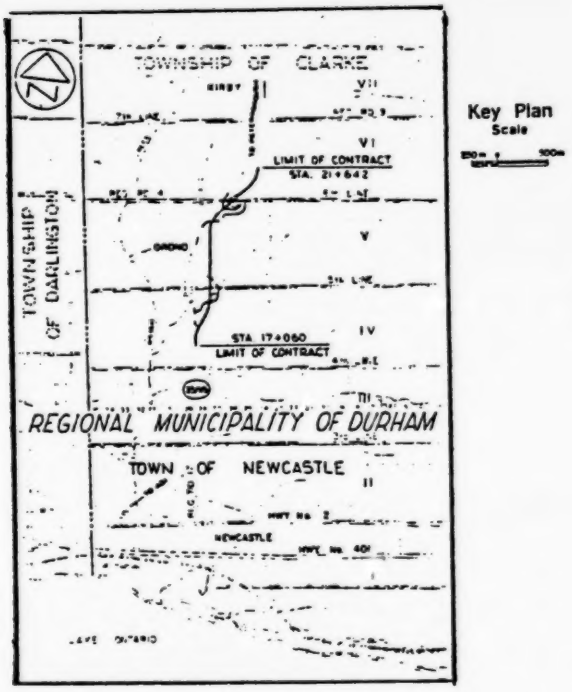


Fig. 3 - Location of Contract 85-39

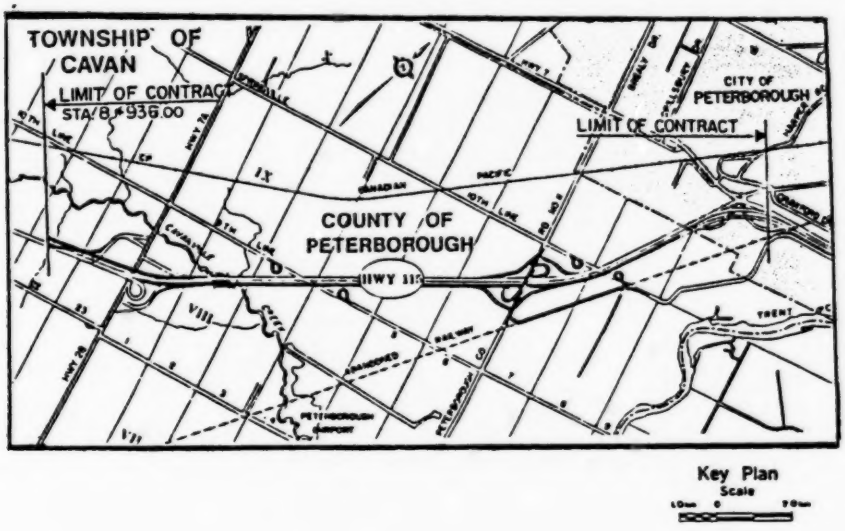


Fig. 4 - Location of Contract 85-40

Because of the excessive pick-up by the contractor's rubber-tired roller and its subsequent replacement, as described in 4.1, another test area developed (Test Area 1c). The conventional rolling train, detailed in 2.2.1, was used only for the first 300 m of the driving lane (Station 17+100 to 17+400). The remainder of the designated conventional rolling train areas were compacted with the two steel drum rollers. The area that was done with the entire conventional rolling train is treated separately in 5.0, to investigate the effect of replacing the rubber-tired roller.

3.2 Contract 85-40

The location of Contract 85-40 is shown in Fig. 4. The test section is located in the eastbound lanes of Highway 115 at Highway 28, from Station 10+115 to 10+680.

The surface course consisted of 40 mm of HL-1 mix. Two test areas were constructed, each extending over the driving lane and the adjacent passing lane. One test area was compacted with the conventional train, and the other with the rubber-coated roller.

Each test area was approximately 400 m long. The location of the test areas can be found in Appendix 1.

4.0 CONSTRUCTION OF THE TEST SECTIONS

4.1 Contract 85-39

The 40 mm surface course was paved on November 7, 1986. The morning was very foggy, and the temperature rose to 13°C in the afternoon. Paving was delayed by the fog and began at 10:00 am. The ambient temperature was 10°C.

Two pavers were used for the test section, one in each lane. The pavers remained about 75 m apart so that traffic could pass between them. The traffic remained on the passing lane only, throughout the day, except when re-routing around the paver.

Paving began in the passing lane with the 55% coarse aggregate DFC mix. The compaction unit was the rubber-coated roller. A Dynapac service representative was on site to train the roller operator in the operation of the machine, and the diesel fuel spray bar. The operator engaged the diesel spray only when necessary, consequently no problems were encountered with the diesel fuel on the pavement.

Before the paving began, the rubber-coated roller was driven on the binder course for approximately 1 km to the start of the test section. When the rubber-coated roller began working on the surface course, the roller pick-up was minimal.

Conversely, the contractor's rubber-tired roller had a serious problem with pick-up. Paving in the driving lane commenced soon after starting the passing lane. The conventional train began compacting the driving lane, but the pick-up by the rubber-tired roller was so severe that it had to be taken off the pavement. It was replaced by a second steel drum roller. As a result, only the first 300 m of the driving lane were compacted by the contractor's usual rolling train (Sta 17+100 to17+400). The remainder of the conventional rolling train areas were compacted by two Dynapac CC5OAs (steel drum vibratory rollers). The first steel drum roller made vibratory passes, and the second only static.

To ensure maximum compaction of the hot mix, the rolling pattern of the rubber-coated roller consisted of four high amplitude vibratory passes over every part of the surface (ie. the roller would pass over any area four times). However, using this rolling pattern, the roller began to bounce on the final pass (indicative of too much rolling). Therefore, the rubber-coated roller continued the four passes on low amplitude only.

Dynapac suggests the addition of a small steel drum roller, used only along the joint, to achieve adequate longitudinal joint compaction. The longitudinal joint was not cold in this test section, so the small roller was not used.

After paving the first 600 m of both lanes, the mix was changed to DFC with 45% coarse aggregate. The mix change was for experimental purposes only, and was not specified in the original contract. The switch, at approximately Station 17+750 (see test area locations in Appendix 1), was done smoothly, with a small transition area.

Half way through the test section (after 1200 m), the rolling trains were exchanged. The rubber-coated roller compacted the driving lane surface course, and the passing lane was rolled with the steel rollers. No problems were encountered in the change over.

After another 600 m, the mix reverted to the 55% coarse aggregate DFC. The final test areas were paved and the test section was completed by 5:00 pm.

The rubber-coated roller produced a tight, closed surface texture when compared with that produced by the conventional train. The surface of the area compacted by the rubber-coated roller felt rougher and the coarse aggregate projections appeared higher than in the control area. However, the difference is not as marked as that in the HL-1 test section on Contract 85-40.

The average temperature of the hot mix as placed was 120°C. No loss in production resulted from using the Dynapac rubber-coated roller as a compaction train.

4.2 Contract 85-40

The test section was paved on October 20, 1986. The day was warm and sunny, with a high temperature of 15°C.

Paving began at 8:30 am. The ambient temperature was 7°C. Only one paver was used in the test section, and the passing lane was paved first. All traffic was kept on the driving lane, during the paving of the passing lane.

The first 400 m of the 40 mm surface course (starting at Station 10+115) were compacted by the conventional rolling train. The average temperature of the hot mix placed on the road was 155°C, and the area was completed without complication.

From Station 10+500 (refer to Appendix 1), the HL-1 mix was compacted by the rubber-coated roller. Initially, there was a substantial amount of pick-up with the rubber-coated roller. For some time there was a band of asphalt pick-up around one drum which made a slight depression in the pavement. A significant amount of diesel fuel had to be used on the cold roller. After 45 min the roller was warm, pick-up was no longer a problem and the diesel fuel could be used sparingly.

The rolling pattern of the rubber-coated roller in the passing lane consisted of four high amplitude vibratory passes plus two static passes. The static passes were used to eliminate roller marks on the surface.

The mix temperature had decreased to approximately 140°C at placement (the temperature was lowered at the plant), and stayed at that temperature throughout the remainder of the test section.

After lunch, traffic was switched to the passing lane and the driving lane was closed. The first 400 m of the driving lane were paved and compacted by the conventional train.

The rubber-coated roller was used on the latter half of the driving lane. The small roller recommended for increased compaction of the longitudinal joint was at the site. However the compaction of the joint area did not appear to be a problem, and the benefit of the small roller was doubtful, so it was not used.

To ensure that maximum compaction was obtained using the rubber-coated roller, the rolling pattern was increased to six vibratory passes plus two static passes in the driving lane. The roller bounced on the final vibratory pass indicating it was probably not needed.

The surface texture produced by the rubber-coated roller was obviously very different than that produced by the conventional train (see Figures 5 and 6). The surface texture of the rubber-coated roller area appeared tight and closed compared to that of the steel drum roller area. The rubber-coated roller section felt much rougher, with higher aggregate projections.

Paving of the test section was completed by 3:00 pm. Use of the rubber-coated roller did not lead to any loss in production.

Fig. 5 - Surface Texture Produced by Conventional Train
(HL-1, Contract 85-40)

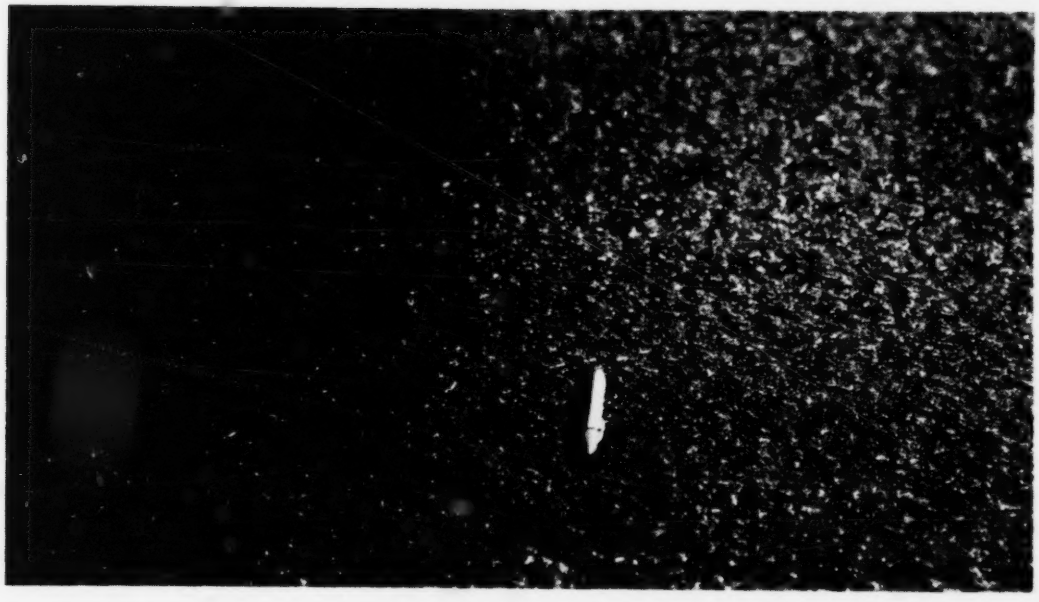


Fig. 6 - Surface Texture Produced by Rubber-Coated Roller
(HL-1, Contract 85-40)

5.0 TEST RESULTS

5.1 Laboratory Testing of Plate Samples

Plate samples were taken of the hot mix placed in the test sections on Contracts 85-39 and 85-40. Their locations (listed in Appendix 2) were determined using random numbers.

The purpose of the plate samples was to monitor the properties of the hot mix placed in the test areas. The samples were tested to determine the flow, stability, percent air voids and voids in mineral aggregate (% VMA), and the asphalt cement content of the hot mix. A sieve analysis was done on the extracted aggregate. The laboratory test data can be found in Appendix 2.

5.1.1 Contract 85-39

Six samples were taken of the 55% coarse aggregate (by volume) DFC. By weight, the hot mix had an average of 55.4% coarse aggregate, with 92.7% of the aggregate retained on the 75 µm sieve (54.7% and 94.5% were required by the mix design).

Stability, asphalt cement content and % VMA were all consistent throughout the test section, and were in the range specified by the mix design. The average corrected void content of the 55% DFC was 1.9%, versus 2.5% required by the mix design. One exception to the low voids was plate sample #5, which had a void content of 2.9%. Flow values ranged from 15.4 to 23.5, with an average of 19.5. The flow specified by the mix design was 16.0.

The sieve analysis data (Appendix 2) showed a consistent aggregate gradation across all the sieves.

Five plate samples were taken of the DFC with 45% (by volume) coarse aggregate. By weight, the average percent coarse aggregate in the samples was 47.8%, with 91.8% of the aggregate retained on the 75 µm sieve (versus 44.6% and 93.2% required by the mix design).

The average stability and % VMA were as designated in the mix design. The average flow was 22.3 versus 16.4 required by the mix design. The asphalt cement content in the plate samples ranged from 4.56% to 4.91%, the mix design specifying 4.6%. The corrected air voids ranged from 1.4% to 2.0%, with an average of only 1.7%. The mix design specified 2.5% air voids.

The gradation of the aggregate, from the sieve analysis, was consistent throughout the plate samples.

5.1.2 Contract 85-40

Six plate samples were taken of the HL-1 placed in the test section on Contract 85-40. From the sieve analysis, the average coarse aggregate content was 55.8%, with 97.8% of the aggregate retained on the 75 µm sieve (versus 52.6% and 98.6% specified in the mix design).

The flow, stability and % VMA values were consistent throughout the plate samples and complied with the mix design. The average corrected air void content was low by 0.4% (2.7% versus 3.1%), as was the % asphalt cement content (4.8% versus specified 5.2%).

The results of the sieve analysis are contained in Appendix 2.

5.2 Compaction and Thickness Test Results

Core samples were taken from both test sections and tested for percent compaction and thickness at the Ministry's head office laboratory. The core locations were determined using random numbers. A list of the core locations by station and offset, and the laboratory results can be found in Appendix 3.

5.2.1 Contract 85-39

Sixty-six core samples were taken form the test section on Contract 85-39. The cores were taken by the contractor within four days of the test section construction.

Six cores were taken from each lane of each test area. Six cores were also taken from the area in the driving lane of 55% DFC where the usual rolling train, including the rubber-tired roller, was the compaction train. In addition, twelve cores were taken along the longitudinal joint. A summary of the core results follows in Table 1.

AREA	% COMP	THICK
1. 55% DFC Steel Drum	93.7	36 mm
1c) 55% DFC Conventional	93.3	36 mm
2. 45% DFC Steel Drum	93.0	34 mm
3. 45% DFC Rubber-Coated	92.0	36 mm
4. 55% DFC Rubber-Coated	92.6	37 mm
Long. Joint	91.7	34 mm

Table 1 - Summary of Core Test Results, Contract 85-39

The DFC containing 55% coarse aggregate, and compacted by the two steel drum rollers, had an average compaction of 93.7%. This is 0.4% higher than the average for the 55% DFC compacted by the conventional rolling train (including the rubber-tired roller).

The steel drum rollers on the 55% DFC achieved an average compaction of 93.7%, versus only 93.0% on the 45% DFC. Likewise, the rubber-coated Dynapac roller achieved an average of 92.6% compaction on the 55% DFC, and only 92.0% on the 45% DFC. Therefore, the compaction of the 55% DFC was approximately 0.6% higher than that of the 45% DFC rolled by the same compaction train.

On the 55% DFC, the steel drum rollers achieved an average of 93.7% compaction versus 92.6% achieved by the rubber-coated Dynapac. Similarly on the 45% DFC, the steel rollers achieved an average compaction of 93.0% versus 92.0% by the rubber-coated roller. The DFC rolled by the rubber-tired roller had approximately 1% less compaction than that rolled by the two steel drum rollers.

Along the longitudinal joint, the average compaction was 91.7% versus an overall average of 92.9% for the test section.

5.2.2 Contract 85-40

Thirty-four core samples were taken from the test section on Contract 85-40. Six cores were taken from each lane of each test area, and five cores along the longitudinal joint in each test area. The cores were taken one day after construction.

AREA	% COMP	THICK
1. Conventional		
Driving and Passing Lanes	95.5	43 mm
Along Long. Joint	96.2	43 mm
2. Rubber-Coated		
Driving and Passing Lanes	95.4	39 mm
Along Long. Joint	96.0	40 mm

Table 2 - Summary of Core Test Results, Contract 85-40

The core results are summarized in Table 2. The average compaction in the test area rolled by the conventional train was 95.5% versus 95.4% in the area compacted by the rubber-coated roller. Along the longitudinal joint, the average compaction in the control area was 96.2%, versus 96.0% in the rubber-coated roller area.

The results show a higher percent compaction along the joint than elsewhere. This is probably because special care was given to the joint due to concern over its compaction.

The rubber-coated roller on Contract 85-40 achieved approximately the same level of compaction as the conventional rolling train.

5.3 Friction Testing

The frictional characteristics of the surface course were to be determined using the brake force trailer. Because the test sections were not constructed until late fall, only the section on Contract 85-40 could be tested. The brake-force trailer was stored for the winter before the test section on Contract 85-39 was completed.

5.3.1 Brake-Force Trailer Results, Contract 85-40

The friction survey on Contract 85-40 was done in early November. The results are summarized in Table 3.

AREA	FRICTION NUMBER
1. Conventional	
Driving Lane	38.9
Passing Lane	35.5
2. Rubber-Coated	
Driving Lane	34.2
Passing Lane	35.1

Table 3 - Summary of Friction Survey Results, Contract 85-40

A high friction number indicates a pavement surface with good frictional characteristics. All of the friction numbers were over 30, indicating good frictional properties. However, the numbers from the area rolled by the conventional train were higher than those from the rubber-coated roller area. In the driving lane, the conventional area had an average friction number of 38.9, versus 34.2 in the rubber-coated roller area. Likewise, in the passing lane, the conventional area had an average friction number of 35.5, versus 35.1.

The results were unexpected, considering the appearance of the surface texture produced by the two compaction trains (as discussed in 4.1 and 4.2). The area will be re-tested to confirm the results, however this can not be done until spring 1987, when the brake-force trailer is brought out of storage.

To explain the friction numbers received, stereo pairs of photographs of the test areas have been requested. Photographs are taken of the pavement surface texture using a specially designed camera box and light source. The colour slides are examined by an experienced photo-interpreter and different texture measurements are taken. The height and width, the angularity and the distribution density of the macro-projections is recorded. The harshness of the surface is also measured.

Results from the photo-interpretation will also be available in the spring. These results may explain why the friction numbers were higher from the conventional test area than from the rubber-coated roller area.

Also, stereo-pairs of photographs will be taken of the test section on Contract 85-39, as well as a friction survey in the spring of 1987. With this additional data, the frictional properties of the test areas in the two test sections can be analyzed in-depth. Until then, with only limited data, no conclusions about the frictional characteristics of the pavement surface can be drawn.

6.0 CONCLUSIONS

1. No problems were encountered with the operation of the rubber-coated roller. Asphalt pick-up by the cold rubber-coated roller was a problem on one contract until the roller warmed up. Once warm, there was no pick-up and the diesel fuel spray bar could be used sparingly. On the other contract, no pick-up was experienced with the rubber-coated roller. No loss in production resulted from the use of the rubber-coated roller.

2. The 55% and 45% DFC compacted by the steel drum rollers had an average compaction 1% higher than the corresponding area compacted by the rubber-coated roller.

3. On the HL-1 mix, the compaction achieved by the conventional rolling train was the same as that achieved by the rubber-coated roller.

4. The compaction of the longitudinal joint, on the HL-1 surface course, was the same in both the conventional train and rubber-coated roller areas.

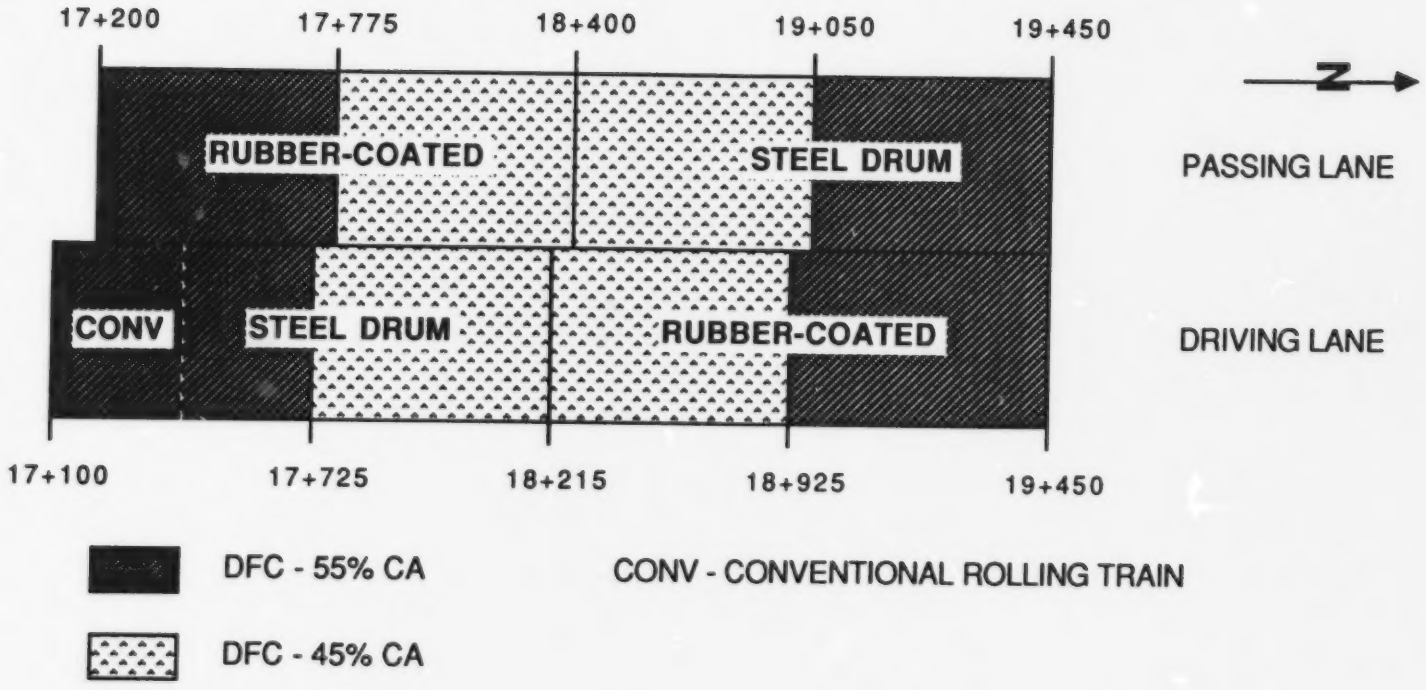
5. No conclusions can be drawn, at this time, concerning the surface frictional properties of the test areas. Further friction survey and photo-interpretation results will be available in the spring of 1987, at which time an in-depth analysis of the frictional properties will be done.

7.0 RECOMMENDATIONS

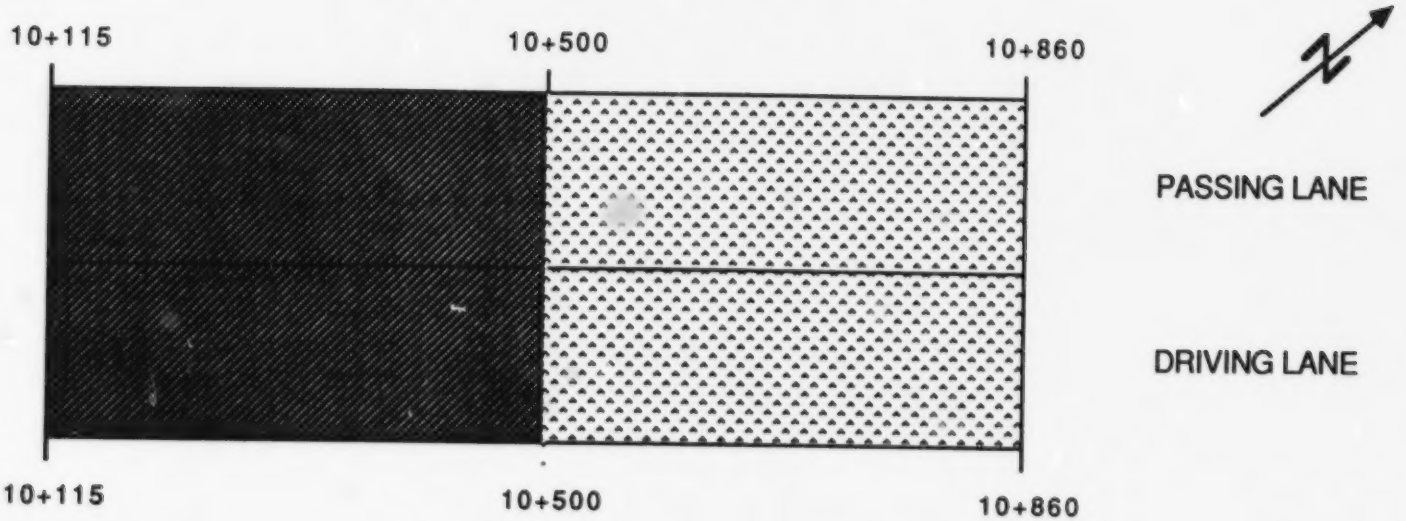
1. In the spring of 1987, a friction survey will be done on both test sections and the results from the photo-interpretation will be available. At this time the frictional properties of the test sections can be analyzed further.

2. Friction surveys should be done and photographs of the surface texture taken every year to monitor the frictional characteristics of the pavement surface.

APPENDIX 1 - LOCATION OF TEST AREAS



Location of Test Areas, Contract 85-39



Location of Test Areas, Contract 85-40

APPENDIX 2 - PLATE SAMPLE RESULTS

AREA	#	STATION	OFFSET	VOIDS	FLOW	STABILITY	VMA	% A.C.	RET 4.75mm	Pass 75µm
			(m)	(%)		(N)	(%)		(%)	(%)
DFC	1	17+400	2.5	1.9	21.2	11323	14.7	4.80	53.9	7.3
55% CA	2	17+450	2.7	1.4	19.2	11187	14.6	4.88	54.9	7.6
	3	17+670	0.9	1.8	20.9	10693	14.8	4.87	56.3	7.6
	4	19+030	0.8	1.7	17.0	10230	14.8	4.85	55.1	7.1
	5	19+290	1.9	2.9	15.4	10026	15.2	4.69	56.7	7.2
	6	19+315	1.9	1.7	23.5	11391	14.8	4.82	55.7	7.2
AVERAGE				1.9	19.5	10808	14.8	4.82	55.4	7.3
MIX DESIGN				2.5	16.0	10700	14.9	4.80	54.7	5.5
DFC	7	17+800	1.2	1.7	21.7	12276	14.4	4.79	45.8	8.4
45% CA	8	18+100	0.9	1.4	21.6	10844	14.7	4.91	45.5	8.8
	9	18+350	3.8	2.0	21.8	11694	14.6	4.58	49.6	8.1
	10	18+475	2.8	1.8	21.8	11245	14.2	4.56	50.2	7.6
	11	18+895	3.5	1.7	24.6	10745	14.8	4.88	47.8	8.2
AVERAGE				1.7	22.3	11361	14.5	4.74	47.8	8.2
MIX DESIGN				2.5	16.4	10800	14.4	4.60	44.6	6.8

Plate Sample Test Results, Contract 85-39

AREA	STATION	OFFSET	VOIDS	FLOW	STABILITY	VMA	% A.C.	RET 4.75	PASS 75
		(m)	(%)		(N)	(%)		(%)	(%)
CONVENTIONAL	10+210	3.1	2.6	13.7	15617	14.7	4.91	55.5	97.7
TRAIN	10+375	1.2	3.2	11.5	13017	14.9	4.79	54.7	97.7
	10+455	1.0	2.2	12.6	13927	14.6	4.81	57.9	97.8
AVERAGE			2.7	12.6	14187	14.7	4.84	56.0	97.7
DYNAPAC	10+630	1.4	2.7	10.8	13814	13.8	4.63	56.8	97.9
ROLLER	10+677	2.0	2.3	12.9	14571	14.8	4.90	54.9	97.8
	10+750	2.5	3.4	10.6	13993	15.2	4.79	55.1	98.0
AVERAGE			2.8	11.4	14126	14.6	4.77	55.6	97.9
OVERALL AVER			2.7	12.0	14157	14.7	4.8	55.8	97.8
MIX DESIGN			3.1	10.8	11800	15.9	5.2	52.6	98.6

Plate Sample Test Results, Contract 85-40

			% RETAINED ON SIEVE								
AREA	STATION	OFFSET	9.5 mm	6.7 mm	4.75 mm	2.36 mm	1.18 mm	600 µm	300 µm	150 µm	75 µm
DFC	17+400	2.5	18	43	53.9	68	77	83	86	90	92.7
55 % CA	17+450	2.7	20	45	54.9	68	77	82	86	89	92.4
	17+670	0.9	21	46	56.3	69	78	83	87	89	92.4
	19+030	0.8	22	45	55.1	69	78	83	87	90	92.9
	19+290	1.9	23	47	56.7	70	78	83	87	90	92.8
	19+315	1.9	21	44	55.7	69	78	83	87	90	92.8
AVERAGE			21	45	55.4	69	78	83	87	90	92.7
DFC	17+800	1.2	19	36	45.8	62	73	80	84	88	91.6
45 % CA	18+100	0.9	17	36	45.5	61	72	79	84	88	91.2
	18+350	3.8	20	41	49.6	64	74	80	85	88	91.9
	18+475	2.8	18	40	50.2	65	75	81	85	89	92.4
	18+895	3.5	16	38	47.8	63	73	80	84	88	91.8
AVERAGE			18	38	47.8	63	73	80	84	88	91.8

Sieve Analysis Results, Contract 85-39

			% RETAINED ON SIEVE								
AREA	STATION	OFFSET	9.5 mm	6.7 mm	4.75 mm	2.36 mm	1.18 mm	600 µm	300 µm	150 µm	75 µm
CONVENT	10+210	3.1	27	49	55.5	62	68	77	89	95	97.7
	10+375	1.2	25	46	54.7	61	66	76	86	94	97.7
	10+455	1.0	27	52	57.9	63	69	78	88	95	97.8
RUBBER-COATED	10+630	1.4	23	48	56.8	63	69	78	89	95	97.9
	10+677	2.0	23	48	54.9	61	67	76	87	94	97.8
	10+750	2.5	24	48	55.1	60	66	75	89	95	98.0

Sieve Analysis Results, Contract 85-40

APPENDIX 3 - CORE SAMPLE RESULTS

Core Sample Locations, Contract 85-39

AREA	CORE #	STATION	O/S (m)
AREA 1 a)	1	17+417	3.6
DRIVING LANE	2	498	0.4
STEEL DRUM	3	543	1.6
55%	4	575	0.5
	5	641	0.6
	6	692	0.8
AREA 1 b)	43	19+110	3.2
PASSING LANE	44	174	1.5
STEEL DRUM	45	249	1.9
55%	46	317	4.2
	47	387	1.7
	48	401	3.6
AREA 1 c)	61	17+117	1.0
DRIVING LANE	62	183	0.6
CONVENTIONAL	63	222	3.0
55%	64	259	2.8
	65	297	1.7
	66	324	0.8
AREA 2 a)	7	17+780	2.6
DRIVING LANE	8	851	1.3
STEEL DRUM	9	977	1.8
45%	10	18+093	1.0
	11	125	2.0
	12	180	1.6
AREA 2 b)	37	18+591	4.0
PASSING LANE	38	675	3.1
STEEL DRUM	39	728	1.0
45%	40	828	2.3
	41	895	1.8
	42	943	4.0
AREA 3 a)	13	18+363	2.2
DRIVING LANE	14	445	0.6
RUBBER-COATED	15	598	3.7
45%	16	662	1.8
	17	797	1.0
	18	850	4.1

Core Sample Locations, Contract 85-39

AREA	CORE #	STATION	O/S (m)
AREA 3 b)	31	17+850	1.9
PASSING LANE	32	905	5.1
RUBBER-COATED	33	18+109	3.7
45%	34	188	4.4
	35	267	3.0
	36	354	3.4
AREA 4 a)	19	19+047	0.8
DRIVING LANE	20	150	4.0
RUBBER-COATED	21	228	0.5
55%	22	344	1.5
	23	379	0.8
	24	425	1.9
AREA 4 b)	25	17+253	1.8
PASSING LANE	26	339	4.3
RUBBER-COATED	27	481	2.3
55%	28	607	0.7
	29	662	2.6
	30	701	5.0
LONG JOINT	49	17+390	
	50	518	
	51	638	
	52	906	
	53	18+110	
	54	197	
	55	461	
	56	549	
	57	821	
	58	19+146	
	59	292	
	60	368	

Core Sample Locations, Contract 85-40

AREA	CORE #	STATION	O/S FROM EP (m)
DRIV LANE	1	10+114	0.9
CONVENT	2	10+179	1.8
	3	10+259	3.0
	4	10+297	0.6
	5	10+371	2.6
	6	10+445	1.5
PASS LANE	13	10+090	1.4
CONVENT	14	10+176	3.0
	15	10+262	2.2
	16	10+290	1.0
	17	10+381	1.5
	18	10+455	1.0
DRIV LANE	7	10+501	1.2
RUBBER-	8	10+572	3.3
COATED	9	10+653	1.8
	10	10+705	1.4
	11	10+779	1.7
	12	10+853	3.0
PASS LANE	19	10+514	2.2
RUBBER-	20	10+557	3.3
COATED	21	10+667	3.3
	22	10+705	2.3
	23	10+784	1.9
	24	10+827	2.8
JT CORES	25	10+145	
CONVENT	26	10+191	
	27	10+253	
	28	10+319	
	29	10+414	
JT CORES	30	10+529	
RUBBER-	31	10+569	
COATED	32	10+675	
	33	10+720	
	34	10+814	

Core Sample Test Results, Contract 85-39

AREA	CORE #	THICK (mm)	% COMP	AVERAGES
AREA 1 a)	1	35	92.8	AVER THICK
DRIVING LANE	2	45	93.3	40
STEEL DRUM	3	39	93.1	
55%	4	43	94.3	AVER COMP
	5	40	93.2	93.5
	6	39	94.0	
AREA 1 b)	43	37	95.1	AVER THICK
PASSING LANE	44	32	93.6	33
STEEL DRUM	45	34	93.0	
55%	46	35	95.2	AVER COMP
	47	28	93.2	93.9
	48	30	93.4	
AVERAGE		**36**	**93.7**	
AREA 1 c)	61	30	92.0	
DRIVING LANE	62	39	92.9	
CONVENTIONAL	63	34	93.2	
55%	64	38	94.2	
	65	36	94.0	
	66	40	93.6	
AVERAGE		**36**	**93.3**	
AREA 2 a)	7	34	93.4	AVER THICK
DRIVING LANE	8	35	90.4	35
STEEL DRUM	9	30	92.6	
45%	10	35	92.1	AVER COMP
	11	40	92.7	92.8
	12	34	95.7	
AREA 2 b)	37	35	93.5	AVER THICK
PASSING LANE	38	31	93.6	33
STEEL DRUM	39	30	93.5	
45%	40	30	92.1	AVER COMP
	41	36	95.1	93.3
	42	37	91.7	
AVERAGE		**34**	**93.0**	

Core Sample Test Results, Contract 85-39

SECTION	CORE #	THICK (mm)	% COMP	AVERAGES
AREA 3 a)	13	32	90.3	AVER THICK
DRIVING LANE	14	32	91.1	36
RUBBER-COATED	15	34	90.9	
45%	16	37	90.8	AVER COMP
	17	43	91.1	90.6
	18	37	89.5	
AREA 3 b)	31	43	95.4	AVER THICK
PASSING LANE	32	31	93.3	36
RUBBER-COATED	33	35	95.4	
45%	34	38	93.6	AVER COMP
	35	35	90.5	93.4
	36	34	92.3	
AVERAGE		36	92.0	
AREA 4 a)	19	45	91.3	AVER THICK
DRIVING LANE	20	28	92.6	38
RUBBER-COATED	21	40	94.1	
55%	22	38	92.4	AVER COMP
	23	38	91.4	92.3
	24	37	92.0	
AREA 4 b)	25	38	93.9	AVER THICK
PASSING LANE	26	33	90.9	37
RUBBER-COATED	27	32	90.4	
55%	28	32	92.3	AVER COMP
	29	43	94.3	92.9
	30	44	95.3	
AVERAGE		37	92.6	
JOINT CORES	49	38	91.3	
	50	37	92.6	
	51	31	92.2	
	52	40	92.4	
	53	38	94.7	
	54	36	92.1	
	55	37	91.1	
	56	32	92.8	
	57	33	89.6	
	58	28	90.4	
	59	29	90.0	
	60	32	90.6	
AVERAGE		34	91.7	
OVERALL AVER		36	92.7	

Core Sample Test Results, Contract 85-40

AREA	CORE #	THICKNESS (mm)	% COMP
DRIV LANE	1	55	95.2
CONVENT	2	37	94.6
	3	40	94.8
	4	37	95.0
	5	38	94.8
	6	45	96.7
PASS LANE	13	44	97.3
CONVENT	14	43	96.8
	15	34	95.9
	16	48	93.8
	17	51	95.8
	18	36	95.7
AVERAGE		42	95.5
DRIV LANE	7	44	95.9
RUBBER-	8	34	94.2
COATED	9	45	96.4
	10	42	97.8
	11	37	93.2
	12	39	95.9
PASS LANE	19	41	96.0
RUBBER-	20	36	95.7
COATED	21	34	97.4
	22	42	93.7
	23	34	95.5
	24	38	93.3
AVERAGE		39	95.4
JT CORES	25	40	96.7
CONVENT	26	45	95.4
	27	37	96.1
	28	46	96.0
	29	47	96.8
AVERAGE		43	96.2
JT CORES	30	38	97.2
RUBBER-	31	33	95.5
COATED	32	45	96.5
	33	47	96.4
	34	39	94.3
AVERAGE		40	96.0